Existing habitat improvements

Water developments

At least 44 springs have been, or are planned to be, developed for wildlife use throughout the project area on state, federal, and private lands (Table 10).

Mineral licks

Several natural mineral licks occur in the study area. Salt blocks containing selenium and/or medication (anthelmintic) blocks have been placed in Oregon and Washington (Table 10). Hells Canyon is considered selenium poor for livestock, and bighorn sheep have selenium levels that would be considered low for domestic sheep. However, there is currently little baseline data on normal selenium levels for bighorn sheep.

Range improvement

Four irrigation, cultivation, and fertilization projects have been conducted in Idaho, Oregon, and Washington (Table 10). Nearly 70,000 acres in Oregon and Idaho have been treated with prescribed and natural burns since 1992. Extensive cooperative weed control efforts by all public agencies are ongoing and increasing under the Tri-State, Tri-County, and Salmon River Weed Management Projects.

III. PROPOSED ACTIONS

Actions taken under the Hells Canyon Initiative will address factors limiting bighorn sheep populations in Hells Canyon. Emphasis is on achieving self-sustaining bighorn sheep populations that, by definition, do not need continuous intensive management. These herds may also be used for relocations elsewhere in the future. Information gathered in the Hells Canyon project will also be available for application to bighorn sheep restoration in other areas. Actions in this project will be consistent with the Hells Canyon National Recreation Area Comprehensive Plan and with actions identified in the Oregon, Idaho, and Washington bighorn sheep management plans (IDFG 1991, ODFW 1992, WDFW 1995). Actions include:

1. reintroductions
2. population monitoring and research
3. habitat monitoring and management
4. harvest regulations
5. information and evaluation

Reintroductions

Relocation of bighorn sheep will be conducted as necessary (when animals are available) to fill unoccupied habitat and augment existing herds. Reintroductions will significantly expedite progress toward project goals because of the relatively slow growth rate of bighorn sheep populations and the slow rate of dispersal into unoccupied habitat. However, reintroductions are a short-term action that must be accompanied by survival and recruitment of existing herds to establish a self-sustaining population. If successful releases of 50 bighorns are made each year for 10 years, several new herds will be established, existing herds will be augmented, and the total number of bighorns in the project area could nearly triple. If, in addition to releasing bighorns, measures can be developed and implemented to counteract disease or other potentially limiting factors and increase the population growth rate to 10%, numbers could increase 370% in 10 years (Fig. 5). Reintroductions will be conducted as long as suitable vacant habitat or understocked habitat that meets release site criteria (see below) is available. Reintroductions are intended to increase the number and size of the bighorn sheep herds in the project area. There is no evidence that reintroductions will increase the growth rate of established herds.

Bighorn sheep will not be released in areas where there is high risk of contact with domestic sheep or goats, or with bighorn sheep that have survived a recent epidemic and are possibly carrying contagious diseases. In supplemental releases or releases adjacent to herds that have had a die-off, fall lamb:ewe ratios of existing herd should be above 25:100 for at least 2 years. Where possible, a minimum of bighorns will be released per introduction with ratios of at least 3 ewes/ram. There should be at least 20 total bighorns (reintroductions plus resident sheep) in supplemental releases. If any bighorns are released on private land, a cooperative plan will be developed to ensure habitat quality is maintained

or improved and reasonable public access is provided.

Release sites

The states of Oregon, Washington, and Idaho have identified a number of potential release sites within the Hells Canyon project area (Schommer et al. 1991, ODFW 1992, Morgan 1995). These sites were chosen based on visual assessment of habitat and accessibility. In order to assess current suitability, these and other sites (Table 11, Fig. 6) have been rated and bighorns will be released at the highest rated sites, contingent on agreement by the states and land management agencies. When sites are rated evenly, reintroductions will be distributed equitably among states. Release sites were rated using the following criteria:

Risk

1. Proximity to active domestic sheep allotments on public land.
2. Proximity to bighorn sheep potentially carrying a lethal *Pasteurella* bacteria (recent die-off or low lamb-ewe ratios).
3. Proximity to private land.
4. Presence of contiguous habitat between release site and 1, 2, or 3.
5. Presence of movement barriers between release site and 1, 2, or 3.

Habitat suitability

1. Amount of potential lambing habitat within a 10 km radius.
2. Amount of potential winter range within a 30 km radius.
3. Distance to adjacent occupied habitat.

Current site rating is presented in Tables 12 - 17. Sites scoring in the top 10 of the first 2 criteria in both categories (low risk and high habitat suitability) were selected as the overall top release sites (Table 18). Several of the sites with the most extensive habitat rank relatively high for risk of contact with domestic sheep, or risk of contact with bighorn sheep in herds affected by the 1995-96 die-off (Table 18). If these risks can be reduced it will improve ranking of these sites for future reintroductions. Habitat modeling information was unavailable for 2 sites that scored in the top 10 for low risk of contact with domestic sheep or bighorn sheep affected by the 1995-96 die-off. These two sites, Deer Creek, Idaho and Asotin Creek, Washington were include in the top-rated sites based on biologists' visual assessment of habitat quality (Table 18).

Disease testing

Any wildlife relocation carries a risk of disease transfer (Cunningham 1996). All

bighorn sheep released in the project area will be tested for presence of or exposure to pathogenic bacteria, viruses, and parasites at capture. The purpose of disease testing is to prevent accidental introduction of additional infectious diseases into the project area and to establish baseline information on relocated bighorn sheep. Disease testing will follow a standard protocol and will fulfill all necessary state, provincial, and national requirements.

Source populations

Obtaining bighorn sheep for release has historically been a factor limiting reintroductions. For the most part, bighorns have been obtained where available and relatively little attempt has been made to select specific source populations. Coggins and Matthews (1996) evaluated success of previous bighorn sheep releases in Oregon and concluded that releases of "nonmigratory" bighorns, defined as bighorns that do not use elevationally distinct winter and summer ranges, were more successful at establishing a self-sustaining population within 10 air miles of the release site than releases of migratory bighorns. However, other authors (Risenhoover et al. 1988) have noted that translocated bighorns often lack the historic migratory patterns that allowed for full utilization of habitat. Migratory bighorns would presumably be able to better utilize high elevation sites, for instance in the Wallowa Mountains and the Wenaha Wilderness. Nonmigratory bighorns may be better adapted to areas along the Snake River canyon, where winter and summer range habitats are at the same elevation and extensive movements increase the potential for contact with domestic livestock or humans. Where possible, the source population will be matched to the release site, and differences in movements and habitat utilization among different source populations will continue to be evaluated through monitoring.

In the past, Oregon and Washington have established 2 herds (Lostine and Hall Mountain) subsequently used for release into new areas. This is desirable from a logistics standpoint because it avoids the difficulty associated with moving animals across state or national borders, and having to compete with other states for allocation of bighorns. The main drawback to this strategy is that the source population has to be a long distance from the release site, or the sheep will attempt to return to their original area (Coggins and Matthews 1996). In addition, logistical constraints of capturing bighorns must be considered, for example, it may not be possible to use helicopters to capture bighorn sheep in designated wilderness areas within the project area. Surplus bighorn sheep from herds within Hells Canyon will be relocated as is feasible. Past and possible future source herds within the project area are Lostine (migratory), Imnaha (nonmigratory), Black Butte (nonmigratory), Asotin (unknown), Redbird (nonmigratory), and lower Hells Canyon, Idaho and Oregon (nonmigratory). Source herds should have fall lamb:ewe ratios greater than 25:100 and an increasing population trend in order to be used for transplants, and release areas must be isolated from the source population.

Until source populations are available within the project area, bighorn sheep will be relocated from outside Hells Canyon. In the past bighorns from several sources have been released into new herds to increase genetic diversity. This may be a legitimate concern, but data collected in Hells Canyon have not provided any demographic or physical evidence of

inbreeding. The herd (Redbird) established from a single source has similar growth rates to other herds and has produced large rams (scoring greater than 190 Boone and Crockett points) including the 3 largest rams taken in Idaho. It is possible there is adequate genetic diversity and mixing among herds within Hells Canyon. There may actually be detrimental consequences of mixing bighorns with differential vulnerability to disease (Sandoval et al. 1987). Information on the disease history of source herds being considered for transplants will be obtained and compared with that of existing herd before proceeding with a relocation.

Monitoring and research

Monitoring and research are designed to evaluate the success of the project, determine causes for success or failure, and guide future direction through adaptive management. Carefully designed methodology is needed to measure and evaluate the multiple interacting factors including habitat, dispersal, predation, and disease, that affect bighorn sheep population growth and productivity. Differences of a few percentage points in population growth rates could have a substantial effect on project success. An increase in population growth rate from 7% to 10% has a similar impact as releasing 30 bighorns per year. Monitoring and research are critical to testing new ideas, understanding what is working and why, and developing methods that could be applied in other areas. Monitoring will be reevaluated annually and adjusted as necessary based on the data collected.

Survival and movements

Bighorns released in the project area will be radio-collared and regularly relocated. Goals are to quantitatively document post-release movements and to monitor extent and causes of mortality. A monitoring plan will be developed by the HCBSRC for each release. This will include frequent (weekly) relocations of radioed sheep for a month post-release and less frequent, regular relocations for the life of the radio collar. Emphasis will be placed on visual observations of bighorns where feasible, in order to detect mortalities as soon as possible. When dead sheep are located, it will be a priority to examine the carcass to collect information on the probable cause of mortality. In areas of low lamb survival, additional monitoring will be conducted to determine when and how mortality is occurring. This information will be used to determine whether predators or disease could be having an impact on project success and whether additional information and/or management actions are needed.

Blood or tissue samples will also be collected from all bighorns released or handled in the project area. This information will be used in conjuction with movement data to determine the relative contribution of bighorns from different source populations and to assess the potential for genetically-based disease resistance in bighorn sheep.

Population size and trend

Annual project-wide surveys will be conducted in a consistent manner. Additional surveys will be conducted where needed. Some herds will be surveyed more intensively to monitor lamb survival (see above). Project surveys will determine population status in an accurate cost-efficient manner, within budget and time constraints. In order to provide accurate and comparable population estimates within the project area, radio-collared bighorns will be used to test and modify as necessary an existing bighorn sheep sightability model (Bodie et al. 1995) to be used during a consistent sampling period. Models can be developed for different survey techniques (fixed-wing, helicopter, and ground surveys).

Disease treatment, monitoring, and research

Disease has apparently historically reduced population growth rates by at least 40% in the project area (Table 5). Disease monitoring, treatment, and research are important components of successful restoration of bighorn sheep in Hells Canyon and elsewhere. All bighorn sheep handled in the project area will be tested for disease according to a standard protocol. Blood samples will be collected for bacterial, viral, chemistry, trace mineral, and genetic testing. Viral and bacterial pharyngeal swabs, ear swabs, external parasites, and fecal samples will also be collected from all bighorns. All bighorns that die in the canyon will be retrieved where possible and will be necropsied using a standard protocol developed in this project.

An emergency disease response plan will be developed prior to, and implemented during and after, disease outbreaks. Summer lamb production and survival will be monitored annually following die-offs to evaluate recovery of the herd. Results of disease testing, information on radio-collared bighorn sheep movements, survival, and productivity; and fall and spring survey information will also provide a basis for decisions regarding future bighorn transplants in and near the die-off area.

Treatment of bighorn sheep including administering anthelmintics, antibiotics, and vaccines will be conducted in an experimental manner in order to assess effectiveness. Preventive and acute disease treatment protocols will be established and included in an emergency response team plan. Treatments will be evaluated and modified as indicated by the data collected. Research may address various aspects of vulnerability to disease, transmission, and disease ecology and will focus on field application. An annual research priority list will be developed by the Hells Canyon Bighorn Sheep Restoration Committee and internal and external research proposals will be ranked and funded accordingly. Agencies may provide internal research review to ensure that bighorn sheep research is consistent with agency management needs.

Habitat evaluation

Landscape level

Habitat modeling will be completed for the remainder of the project area to provide coarse scale, general, habitat information. Information on bighorn sheep movements will be used with this broad scale habitat data to track herd areas and movement and migration corridors. Coarse scale habitat information will also be used to rank reintroduction sites and identify areas for habitat acquisition or protection.

Fine scale

Although extent of habitat does not appear to be limiting current bighorn sheep populations, the negative relationship between population growth rate and herd size suggests that habitat quality could be affecting population growth. In the future, habitat changes, such as spread and/or control of noxious weeds could also affect population growth. Habitat monitoring will be designed to assess effects of habitat quality (abundance and quality of forage) on productivity, population growth, dispersal, and vulnerability to disease. Vegetation plots have been established by the USFS, BLM, and IDFG within the project area. These plots will be evaluated for their applicability to this project. New plots may also be established. Plots will be monitored annually to estimate forage availability and changes in species composition in association with weather, grazing, and other factors.

Habitat management

Public land domestic sheep and goat allotments

Domestic sheep and goats grazing on public lands could significantly affect the success of this project if diseases are transferred to bighorn sheep. Land management agencies will be encouraged to manage grazing within the project area in a manner compatible with project goals. Use of pack goats should be restricted in areas where there is a likelihood of contact with bighorn sheep. State agencies will capture bighorn sheep that have come into contact with domestic sheep or goats and remove them from the wild.

Private domestic sheep and goats

Although the majority of the project area is in public ownership, disease transfer from privately-owned domestic sheep and goats may also significantly affect restoration of bighorn sheep. It is expected that interaction between bighorn sheep and private landowners will become more frequent as populations of both increase within suitable habitat in the project area. Education of private landowners grazing domestic sheep and goats in bighorn habitat through dissemination of information and personal contact is a priority. Educational efforts

will focus on explaining the conflict between wild sheep and domestic sheep and goats, suggesting ways to reduce opportunity for disease transfer, and encouraging landowners to contact agencies when bighorn sheep come into contact with their livestock.

Future habitat improvements

Habitat protection and improvement actions are listed in order of priority. Habitat acquisition and easements are high priority and will emphasize protection of critical habitat. Habitat improvements are intended to address site-specific issues such as conflicts between bighorns and humans, local distribution and movements of bighorns, or specific factors that have been shown to limit numbers of bighorn sheep in the area.

Habitat acquisition and easements

Support for acquisition of habitat and/or protective easements within the project area will be prioritized based on contribution to bighorn sheep restoration, availability of land or cooperators, and cost-effectiveness of purchase or easement.

Range improvement

Noxious weed management will be coordinated with ongoing interagency actions by the states of Oregon, Idaho, and Washington, the USFS, BLM, and Natural Resources Conservation Service. Assistance may be provided in future noxious weed control efforts where weeds threaten bighorn sheep habitat.

Prescribed (and natural) fire may be beneficial for bighorn sheep in certain areas. Areas where prescribed fire could be used to improve bighorn sheep habitat will be evaluated on a site-specific basis and treated as appropriate in conjunction with land management agencies.

Fertilization and/or cultivation of range plots may be conducted as appropriate to alter distribution or movements of bighorn sheep.

Salting and mineral licks

Salt blocks or mineral licks may be placed where needed to disperse bighorn sheep and avoid conflict between bighorns and humans or livestock. The benefits and drawbacks of salting will be assessed when establishing salt or mineral licks.

Water developments

Existing water developments will be maintained and monitored for evidence of bighorn sheep use. Additional sites may be developed based on site-specific information.

Harvest

Bighorn sheep harvest will continue to be managed and regulated by individual states. States will cooperate in developing herd goals and setting seasons where herds overlap state boundaries or where harvest in one herd could affect adjacent herds.

Information and evaluation

Plan evaluation

This restoration plan will be revised at 5-year intervals, or as needed, to reflect the most current information and management direction in the project area.

Publications and reports

All project partners will contribute data and reports to the project coordinator to be summarized in an annual report due 31 July. The annual report will include accounting and evaluation of all activities conducted during the previous year and proposals and project goals for the coming year. This will include reports on the status of all releases and herds, including estimated population size and growth rate, lamb:ewe ratio, and herd area. A summary and analysis of any disease information collected, including that collected at capture of bighorns to be released in the project area, will also be included. Reports on any control actions, habitat management activities, research, and harvest information will be included. Peer-reviewed publication of data is encouraged and all partners in projects will be acknowledged as appropriate.

The project coordinator will also provide monthly project updates to all project partners.

Peer review

External biologists will be invited to an annual meeting and/or as needed by the Hells Canyon Bighorn Sheep Restoration Committee to evaluate project progress. External biologists may be asked to review written reports and meet with the committee to provide recommendations for future direction.

Public information

Public outreach is an important component of the project and may include developing a newsletter, an adopt-a-sheep program, putting together slide shows or videos and giving presentations, working with volunteers, giving tours, establishing interpretive sites and developing a logo for t-shirts, hats, and a letterhead. States will coordinate press releases to inform the public about activities and project progress. Interested individuals and organizations outside the Hells Canyon Bighorn Sheep Restoration Committee will receive an annual summary of project activities.

Budget

Funding requests

Internal and external project proposals will be submitted to the Hells Canyon Bighorn Sheep Restoration Committee by July 31 for discussion at an annual August meeting. Project proponents will be invited to present their proposals at this meeting. Proposals will be rated using a consistent set of criteria established by the committee. Recommendations will go to FNAWS to be discussed at their fall quarterly board meeting and funding allocation will be announced by November 1.

Budget variances

It is recognized, that as this project develops, annual budget needs may vary significantly. Currently, the 5-year budget projection is a conservative estimate of funding levels necessary to initiate the project. With sufficient additional funding, the project could be expanded dramatically, particularly in the areas of research, habitat improvement, and securing critical habitat. Annual budgets will be adjusted as needed based on project needs and funding availability.

Projected costs for the Hells Canyon Initiative

	Annual Cost 1997 - 2002 (5-year projection)
Reintroduction (50 bighorns/year)	
Salaries	$5,000.00
Travel	$5,000.00
Trapping supplies	$2,000.00
Radiocollars	$12,000.00
Helicopter (as needed depending on capture and release locations)	$0 - 25,000
Subtotal of annual costs for reintroductions	**$24,000 - 49,000**
Research *(costs are estimates and would be project dependent)*	
Disease Research	$35,000.00
Genetics Research	$20,000.00
Population ecology	$20,000.00
Subtotal of annual costs for research	**$75,000.00**
Habitat improvements *(costs are estimates and would be project dependent, does not include habitat acquisition)*	
Weed control	$30,000.00
Water developments	$3,000.00
Other (Prescribed fire, food plots)	$1,000.00
Subtotal of annual costs for habitat improvements	**$36,000.00**
Monitoring and Management	
Equipment - Computer, Receivers, Camera, Scope, etc.	$5,000.00
Salaries	$66,000.00
Operations - Aircraft time, travel, per diem	$35,000.00
Subtotal of annual costs for monitoring and management	**$106,000.00**
Annual Project Cost 1997 - 2002	**$241,000 - 266,000**

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Table 1. Hells Canyon project area bighorn sheep herd sizes, 1995-96.

Herd name	Total	Lambs:100 ewes	Rams:100 ewes
Black Butte, WA	55	6	11
Asotin, WA	9	-	-
Wenaha, OR/WA	120	40	29
Lost Prairie/Mt. View, OR/WA	43	25	42
Lower Hells Canyon, OR	25	11	25
Upper Joseph Creek, OR	20	30	40
Lower Imnaha, OR	130	63	90
Upper Hells Canyon, OR	25	60	160
Lostine, OR	80	43	49
Bear Creek, OR	35	75	150
Sheep Mountain, OR	65	44	72
Redbird, ID	60	48	57
Lower Hells Canyon, ID	25	8	50
Upper Hells Canyon, ID	5	0	0
AVERAGE	50	35	60
TOTAL	697		

Table 2. Bighorn sheep transplants in Hells Canyon and the Wallowa Mountains through 1996.

Date	State	Release Location	Total	Ewes	Rams	Female Lambs	Male Lambs	Source[a]
April 1971	Oregon	Short Creek, Black Mountain	20	12	8	0	0	Jasper National Park, Alberta
April 1971	Oregon	Lostine River	20	11	4	4	1	Jasper National Park, Alberta
31 Jan 1975	Idaho	Granite Creek	10	7	1	0	2	Panther Creek, Salmon R., Idaho
January 1976	Oregon	Bear Creek	17	7	3	3	4	Lostine, Oregon (Jasper NP)
22 Jan 1976	Idaho	Granite Creek	11	3	5	1	2	Panther Creek, Salmon R., Idaho
18 Dec 1977	Oregon	Black Mountain, Battle Creek	5	2	2	0	1	Lostine, Oregon (Jasper NP)
January 1977	Oregon	Bear Creek	8	2	0	2	4	Lostine, Oregon (Jasper NP)
January 1977	Wash.	Joseph Creek WRA	9	6	1	1	1	Hall Mtn., Wash. (Banff NP)
Jan - Feb 1979	Oregon	Battle Creek	9	1	3	2	3	Lostine, Oregon (Jasper NP)
04 Jan 1979	Oregon	Cow Creek, Imnaha River	15	9	5	0	1	Panther Creek, Salmon R., Idaho
12 Jan 1979	Idaho	Bernard Creek	7	7	0	0	0	Panther Creek, Salmon R., Idaho
9-29 Dec 1979	Oregon	Battle Creek	12	1	1	6	4	Lostine, Oregon (Jasper NP)
8 Feb. 1980	Oregon	Hells Canyon Creek	8	5	2	0	1	Lostine, Oregon (Jasper NP)
31 Jan 1981	Wash.	Joseph Creek WRA	10	6	4	0	0	Lostine, Oregon (Jasper NP)
20 Jan 1982	Wash.	Joseph Creek WRA	10	5	4	0	1	Thompson Falls, Montana
January 1982	Oregon	Imnaha River, Hass Ridge	10	4	1	3	2	Lostine, Oregon (Jasper NP)
January 1983	Wash.	Wenaha Canyon	15	8	3	2	2	Hall Mtn., Wash (Banff NP/MT)
January 1983	Oregon	Wenaha Canyon	15	7	3	1	4	Lostine, Oregon (Jasper NP)
07 Jan 1984	Idaho	Captain John Creek, Craig Mt.	17	7	8	1	1	Whiskey Mountain, Wyoming

[a] Original source location in parentheses where source herd was established from a transplant (see Table 3)

Table 2, cont'd. Bighorn sheep transplants in Hells Canyon and the Wallowa Mountains through 1996.

Date	State	Release Location	Total	Ewes	Rams	Female Lambs	Male Lambs	Source[a]
05 Feb 1984	Oregon	Imnaha River, Hass Ridge	11	8	3	0	0	Panther Creek, Salmon R., Idaho
December 1984	Oregon	Wenaha Wildlife Area	28	15	7	3	3	Cove Creek, Salmon R., Idaho
18 Dec. 1985	Oregon	Bear Creek	12	9	2	0	1	Ebenezer Cr., Salmon R., Idaho
18 Apr 1987	Wash.	Joseph Creek WRA	1	0	1	0	0	WSU (Hall Mtn.)
January 1986	Wash.	Wenaha	14	6	3	4	1	Hall Mtn. (Banff NP/MT)
January 1989	Wash.	Joseph Creek WRA	9	6	1	1	1	Thompson Falls, Montana
23 January 1990	Oregon	Sheep Mountain	21	8	5	3	5	Tarryall, Colorado
04 Jan 1990	Idaho	Granite Creek	30	18	6	2	4	Whiskey Basin, Wyoming
03 Feb 1990	Oregon	Sheep Mountain	9	6	0	3	0	Cottonwood Creek, Colorado
Dec 1991	Wash.	Asotin Creek	6	3	1	1	1	Hall Mtn. (Banff NP/MT)
23 Dec 1993	Oregon	Cherry Creek	9	6	2	1	0	Wildhorse Isl., MT (Sun River, MT)
1994	Wash.	Asotin Creek	9	4	2	1	2	Hall Mtn. (Banff NP/MT)
11 Feb 1994	Oregon	Cook Creek/Downey Creek	14	10	3	1	0	Wildhorse Isl., MT (Sun River, MT)
10 Feb 1995	Oregon	Cottonwood Creek	16	5	2	4	5	Cardinal River, Alberta
10 Feb 1995	Oregon	Jim Creek	22	15	0	5	2	Cardinal River, Alberta
7 Feb 1995	Oregon	Sheep Mountain	12	6	1	1	2	Cardinal River, Alberta
Feb 1995	Oregon	Sheep Mountain	2	0	0	0	2	Lostine, OR (Jasper NP/ Salmon R.)
Total	35 transplants	Oregon - 22, Idaho -5 Washington -8	451	229	96	55	59	
				52%	22%	13%	13%	

[a] Original source location in parentheses where source herd was established from a transplant (see Table 3)

Table 3. Source populations for Hells Canyon project area bighorn sheep herds.

Herd	Source population	No. released	Date
Black Butte	Waterton Lakes (via Hall Mountain)	9	1977
	Jasper National Park (via Lostine)	10	1981
	Thompson Falls, Montana	10	1982
	Waterton Lakes/Thompson Falls (via Hall Mountain)	1	1987
	Sun River, Montana	10	1989
Redbird	Whiskey Basin, Wyoming	17	1984
Upper Hells Canyon, OR	Jasper National Park	20	1971
	Jasper National Park (via Lostine)	5	1977
	Jasper National Park (via Lostine)	9	1979
	Jasper National Park (via Lostine)	20	1979-80
Upper Hells Canyon, ID	Salmon River, Idaho	10	1975
	Salmon River, Idaho	11	1976
	Salmon River, Idaho	7	1979
	Whiskey Basin, Wyoming	30	1990
Lower Imnaha, OR	Salmon River, Idaho	15	1979
	Jasper National Park (via Lostine)	10	1982
	Salmon River, Idaho	11	1984
Lower Hells Canyon, OR	Wildhorse Island, Montana	23	1993-94
	Cardinal River, Alberta	22	1995
Wenaha, OR/WA	Waterton Lakes/Thompson Falls (via Hall Mountain)	15	1983
	Jasper National Park (via Lostine)	15	1983
	Cove Creek, Salmon River	28	1984

Table 3, cont'd. Source populations for Hells Canyon project area bighorn sheep herds.

Herd	Source population	No. released	Date
Wenaha	Waterton Lakes/Thompson Falls (via Hall Mountain)	14	1986
Sheep Mountain	Tarryall, Colorado	30	1990
	Cardinal River, Alberta	10	1995
	Jasper National Park /Salmon River, Idaho (via Lostine)	2	1995
Bear Creek	Jasper National Park (via Lostine)	17	1976
	Jasper National Park (via Lostine)	8	1977
	Waterton Lakes/Thompson Falls (via Hall Mountain)	11	1984
	Salmon River, Idaho	12	1985
Lostine	Jasper National Park, Alberta	20	1971
	Salmon River, Idaho (originally released at Minam)	12	1985
Asotin Creek	Waterton Lakes/Thompson Falls (via Hall Mountain)	6	1991
	Waterton Lakes/Thompson Falls (via Hall Mountain)	9	1994

Table 4. Permits and harvest of bighorn sheep in Hells Canyon through 1996.

State	Herd	Total No. Permits	Total No. Harvested[a]	No. Permits 1996	1996 Season
Washington	Black Butte	17	19	0	9/15 - 10/11
	Mountain View	8	6	1	9/15 - 10/11
	Wenaha	16	14	1	9/15 - 10/11
Idaho	Redbird	6	9	1	8/30 - 10/13
	Upper Hells Canyon	20	11	0	-
Oregon	Imnaha	48	45	6	9/6 - 9/17 10/16 - 10/27
	Lostine	63	55	1	9/6 - 9/17
	Joseph Creek	9	7	0	-
	Bear Creek	4	3	1	9/6 - 9/17
	Lower Hells Canyon	3	3	0	-
	Wenaha	12	12	2	10/12 - 10/31
	Sheep Mountain	1	1	1	9/6 - 9/17
Total		207	185	14	

[a] Number of bighorns harvested includes auction and lottery tags.

Table 5. Demography of Hells Canyon bighorn sheep herds 1971 - 1996.

Herd	Year first established	Total bighorns released	Years survey data	Lambs:100 ewes *x (sd)*	Rams:100 ewes *x (sd)*	Average annual population growth rate [a]	Average annual population growth rate exclusive of die-offs
Upper Hells Canyon, Ore.	1971	54	18	38 (30.8)	47 (50.9)	1.04	
Lostine [b]	1971	20	18	41 (19.9)	51 (15.9)	1.05	1.15
Upper Hells Canyon, Idaho	1975	58		14 (23.3)	50 (37.1)	0.93	1.22
Black Butte	1977	39	21	49 (14.1)	54 (18.7)	1.09	1.18
Imnaha	1979	36	17	58 (14.2)	70 (22.3)	1.09	1.09
Wenaha	1983	57	11	43 (12.4)	46 (8.7)	1.07	1.10
Redbird/Lower Hells Canyon, Idaho	1984	17	5	29 (9.0)	57 (13.8)	1.13	1.13
Bear Creek [c]	1985	36	10	54 (17.2)	70 (45.3)	1.10	1.12
Lower Hells Canyon, Ore.	1985	22	11	46 (29.4)	35 (34.6)	1.06	1.10
Lost Prairie/Mountain View		0	3	39 (20.1)	32 (15.0)	0.91	0.91
Joseph Creek	1987	16	9	76 (19.6)	76 (89.3)	1.13	1.15
Sheep Mountain	1990	42	7	30 (15.5)	69 (4.2)	1.22	1.22
Asotin	1991	15	5	-	-	-	-
Average		28	9.9	41 (15.8)	52 (14.2)	1.07 (0.08)	1.12 (0.08)

[a] Average annual herd growth rates (lambda) were calculated as $\Sigma\ (N_{(t)}/N_{(t-1)})/(t-1)$. Relocated sheep were excluded from the population total (N) in the year of the release but were included in subsequent years. No corrections were made for 0 - 6 rams harvested per herd/per year (~200 rams total) since 1975 (Table 3).

[b] From 1976 to 1986, 152 bighorns were transplanted out of the Lostine herd.

[c] Bighorns were first released in Bear Creek in 1976, but the herd was not established until after a 1985 release.

Table 6. Comparison of Hells Canyon bighorn sheep herd annual growth rates after initial release and in subsequent years.

Herd	Initial growth rate[a] *x (sd)*	Subsequent growth rate *x (sd)*	P value
Lostine	1.37 (0.23)	1.10 (0.12)	0.01
Black Butte	1.29 (0.43)	1.19 (0.23)	0.57
Imnaha	1.17 (0.03)	1.10 (0.14)	0.45
Sheep Mountain	1.46 (0.77)	0.96 (0.16)	0.46
Average	1.32 (0.12)	1.08 (0.09)	0.10

[a] initial growth rate = 2-4 years after release.

Table 7. Comparison of 5 Rocky Mountain bighorn sheep habitat models.

HABITAT COMPONENT	Gudorf and Sweanor 1996	Shirokauer 1996	Smith et al. 1991	Dunn 1993	Johnson and Ringo 1995
ESCAPE TERRAIN					
Slope	27°<slope<85°	27°≤ slope≤ 60°	slope ≥60%	slope ≥60%	slope >60%
Buffer	300m or land areas ≤1000m wide bounded on ≥2 sides by escape terrain (500m)	300m	300m or land areas ≤1000m wide bounded on ≥2 sides by escape terrain (500m)	5 km	0.5 mi (800m)
Minimum area	1.6 ha	1.6 ha	na[1]	5 km^2	min 8 mi^2 escape and forage
HORIZONTAL VISIBILITY	≥62% (55%) visibility	high visibility =barren (<15% vegetative cover), rocky reef (>50% rock), grassland (including shrub patches, <15% forest cover), conifer 15-39% canopy cover. low visibility =conifer w/>40% canopy cover, aspen	≥80% visibility low visibility = shrub communities with mean height > 0.5m, riparian areas with dense understory, heavily forested areas, open forest with understory > 0.5m	≤ 25% canopy cover	>35% forage cover
WATER SOURCES	≤ 3.2 km from water	lambing only	≤ 3.2 km from water	≤ 3.2 km from water	≤ 1.6 km from water
HUMAN USE AREAS	150m buffer on a case by case basis	na	100m buffer around trails, roads, dwellings, campgrounds, 150m buffer around airports, mines, tramways, campgrounds, ski resorts	200m buffer around primitive roads/trails, 500m buffer around improved roads, recreation sites, housing developments	na

Table 7, cont'd. Comparison of 5 Rocky Mountain bighorn sheep habitat models.

HABITAT COMPONENT	Gudorf and Sweanor 1996	Shirokauer 1996	Smith et al. 1991	Dunn 1993	Johnson and Ringo 1995
DOMESTIC LIVESTOCK	≥16 km from domestic or exotic sheep	na	no possibility of contact with domestic sheep	≥15 km from domestic sheep	na
SUMMER RANGE	suitable habitat slopes <27°	suitable habitat within 300m of escape terrain	areas w/in 300 m of but not including escape terrain, HV > 80%, min. 8.4-9.7 km^2	low elevation suitable habitat ≤ 200m from escape terrain	na
WINTER RANGE	suitable habitat, aspect 136° - 224°, snowpack ≤ 25 cm	suitable habitat, aspect 135°-270°, elevation < 6,000'. Winter ranges w/in 120m combined (see comments).	Suitable habitat, ≤25cm snowpack, 135°-225°, min of 6.5 km^2	high elevation suitable habitat, snowfree	not delineated, all habitat defined as <4,000', min of 8 mi^2 forage + escape or 4 mi^2 within 0.5 mi of 8 mi^2 block
LAMBING RANGE	escape terrain, aspect 46°-314°, ≤1 km from water, ≥2 contiguous ha	escape terrain, ≤1 km from water, ≥2 contiguous ha	escape terrain 90° - 270°, ≤1 km from water, ≥2 contiguous ha, min total ≥ 360 ha	na	na
MOVEMENT ZONES	patches connected by areas w/HV=30 - 50% < 4.5km apart or HV <30% < 100m apart	na	na	na	na
BARRIERS	case by case basis, horizontal visibility (HV) < 30% > 100m wide	canals, reservoirs, areas of low visibility > 120m wide	wide rivers, lakes, reservoirs, dense vegetation > 100m wide, sheer cliffs, valleys, fencing, major highways, centers of human activity.	na	na

Table 7, cont'd. Comparison of 5 Rocky Mountain bighorn sheep habitat models.

HABITAT COMPONENT	Gudorf and Sweanor 1996	Shirokauer 1996	Smith et al. 1991	Dunn 1993	Johnson and Ringo 1995
COMMENTS	min. of 9km^2 of suitable habitat	winter ranges w/in 120m combines, then winter ranges <1.5km^2 eliminated. Used FRAGSTATS to report mean patch size, nearest neighbor index, contagion.	minimum of 32 km^2 habitat or 17 km^2 core habitat. Probability model (PATREC) is more detailed.	herds ≤ 15 km apart form metapopulation. Escape terrain patches ≤ 200m apart combined. Contiguity index calculated by comparing size and distance of each escape terrain patch 2 km from patch center.	